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LAKE ST. CROIX, WASHINGTON COUNTY, MINNESOTA, AND ST. CROIX AND PIERCE COUNTIES, WISCONSIN

Pacific Northwest Environmental Research Laboratory

Prepared for:

National Environmental Research Center, Corvallis
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Minnesota National Guard

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16. ABSTRACT
Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivded according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

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REPORT
ON
LAKE ST. CROIX
WASHINGTON COUNTY, MINNESOTA, AND
ST. CROIX AND PIERCE COUNTIES, WISCONSIN

EPA REGION V

WORKING PAPER No. 122

WITH THE COOPERATION OF THE

MINNESOTA POLLUTION CONTROL AGENCY

AND THE

MINNESOTA NATIONAL GUARD

JANUARY, 1975

1a

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Minnesota Pollution Control Agency for professional involvement and to the Minnesota National Guard for conducting the tributary sampling phase of the Survey.

Grant J. Merritt, Director of the Minnesota Pollution Control Agency, John F. McGuire, Chief, and Joel G. Schilling, Biologist, of the Section of Surface and Groundwater, Division of Water Quality, provided invaluable lake documentation and counsel during the course of the Survey; and the staff of the Section of Municipal Works, Division of Water Quality, were most helpful in identifying point sources and soliciting municipal participation in the Survey.

Major General Chester J. Moeglein, the Adjutant General of Minnesota, and Project Officer Major Adrian Beltrand, who directed the volunteer efforts of the Minnesota National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

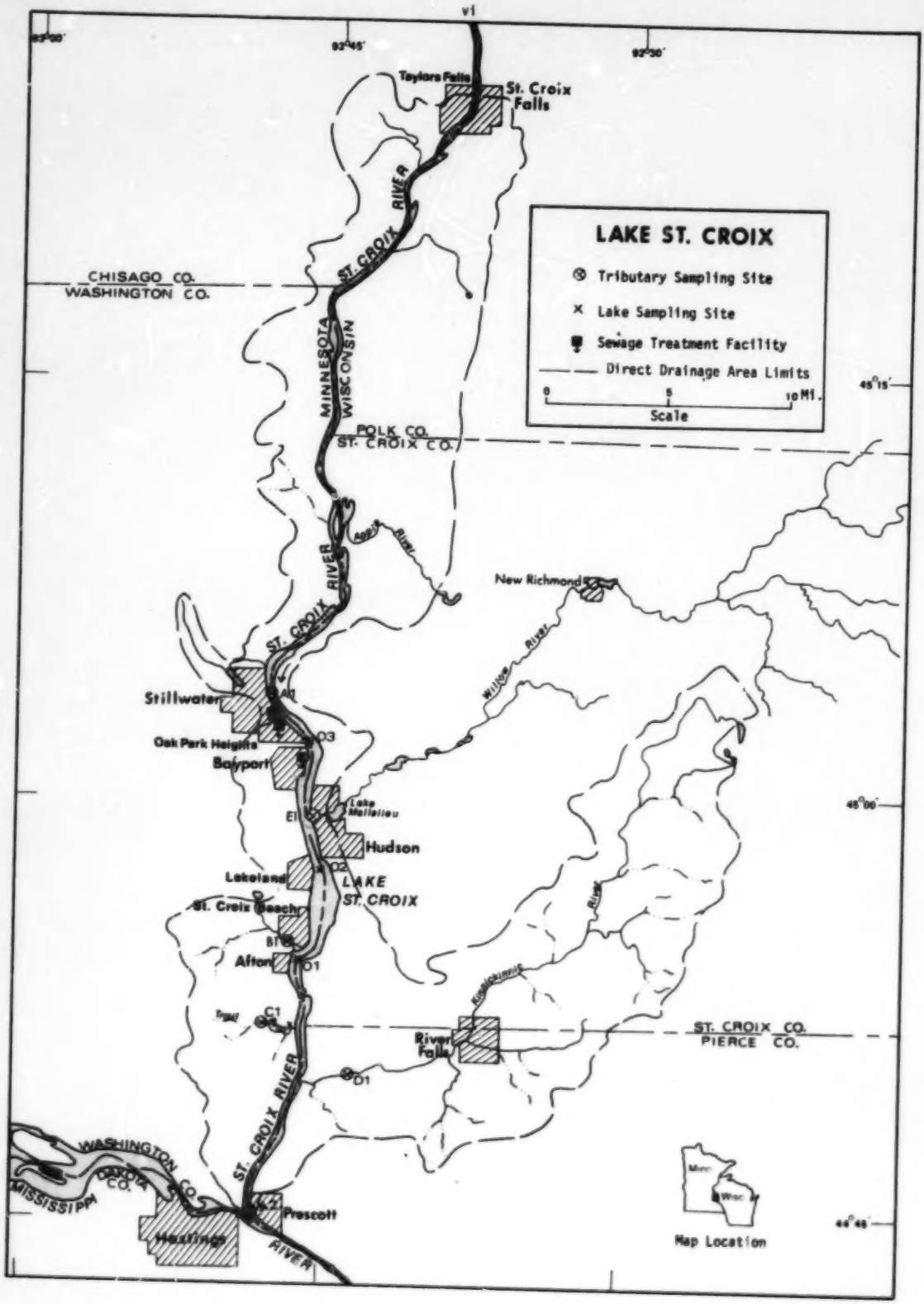
NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF MINNESOTA

LAKE NAME	COUNTY
Albert Lea	Freeborn
Andrusia	Beltrami
Badger	Polk
Bartlett	Koochiching
Bear	Freeborn
Bemidji	Beltrami
Big	Stearns
Big Stone	Big Stone, MN; Roberts, Grant, SD
Birch	Cass
Blackduck	Beltrami
Blackhoof	Crow Wing
Budd	Martin
Buffalo	Wright
Calhoun	Hennepin
Carlos	Douglas
Carrigan	Wright
Cass	Beltrami, Cass
Clearwater	Wright, Stearns
Cokato	Wright
Cranberry	Crow Wing
Darling	Douglas
Elbow	St. Louis
Embarass	St. Louis
Fall	Lake
Forest	Washington
Green	Kandiyohi
Gull	Cass
Heron	Jackson
Leech	Cass
Le Homme Dieu	Douglas
Lily	Blue Earth
Little	Grant
Lost	St. Louis

LAKE NAME	COUNTY
Madison	Blue Earth
Malmedal	Pope
Mashkenode	St. Louis
McQuade	St. Louis
Minnetonka	Hennepin
Minnewaska	Pope
Mud	Itasca
Nest	Kandiyohi
Pelican	St. Louis
Pepin	Goodhue, Wabasha, MN; Pierce, Pepin, WI
Rabbit	Crow Wing
Sakatah	Le Sueur
Shagawa	St. Louis
Silver	McLeod
Six Mile	St. Louis
Spring	Washington, Dakota
St. Croix	Washington, MN; St. Croix, Pierce, WI
St. Louis Bay	St. Louis, MN; Douglas, WI
Superior Bay	St. Louis, MN; Douglas, WI
Swan	Itasca
Trace	Todd
Trout	Itasca
Wagonga	Kandiyohi
Wallmark	Chisago
White Bear	Washington
Winona	Douglas
Wolf	Beltrami, Hubbard
Woodcock	Kandiyohi
Zumbro	Olmstead, Wabasha


LAKE ST. CROIX
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Facility
Direct Drainage Area Limits
0 5 10 Mi.
Scale
Taylors Falls
St. Croix Falls
CHISAGO CO.
WASHINGTON CO.
POLK CO.
ST. CROIX CO.
ST. CROIX RIVER
MINNESOTA
WISCONSIN
New Richmond
Willow River
Stillwater
Oak Park Heights
Bayport
Lake Mallalieu
Hudson
Lakeland
LAKE ST. CROIX
St. Croix Beach
Afton
Trail
River Falls
ST. CROIX CO.
PIERCE CO.
WASHINGTON CO.
OAKDALE CO.
MISSISSIPPI
Hastings
Prescott
RIVER
Map Location
92°30'
92°45'
45°15'
45°00'
44°45'

LAKE ST. CROIX*

STORET NO. 27A7

I. CONCLUSIONS

A. Trophic Condition:

Survey data show that Lake St. Croix is eutrophic. Of the 60 Minnesota lakes sampled in the fall of 1972, when essentially all were well-mixed, 14 had less mean total phosphorus, 13 had less mean dissolved phosphorus, and 35 had less mean inorganic nitrogen. Of all 80 Minnesota lakes sampled, 45 had greater mean chlorophyll a, and 36 had greater Secchi disc transparency.

Reportedly, no particular aquatic nuisance problems are indicated for Lake St. Croix, although an algae bloom occurred in the summer of 1974 (Schilling, 1974).

B. Rate-Limiting Nutrient:

There was a loss of nitrogen in the assay sample and the results of the algal assay are not indicative of conditions in the lake at the time of sampling. However, the lake data indicate nitrogen limitation in June and August and phosphorus limitation in November.

C. Nutrient Controllability:

1. Point sources--During the sampling year, Lake St. Croix received a total phosphorus load at a rate of 79 lbs/acre/yr

* In this report, Lake St. Croix is considered to extend from the St. Croix River bridge at Stillwater, Minnesota, to the U.S. 10 highway bridge just upstream from the confluence of the St. Croix River with the Mississippi River.

(8.9 $g/m^2/yr$) or more than four times that proposed by Vollenweider (in press) as "dangerous"; i.e., a eutrophic rate (see page 14). Now, Vollenweider's model may not be applicable to water bodies with very short hydraulic retention times, and Lake St. Croix has a relatively short mean retention time of 23 days. However, the lake retained (accumulated) about 33% of the applied phosphorus load during the sampling year, and it is likely that the Vollenweider loading rates have some significance in this case.

The Minnesota Pollution Control Agency regulations require phosphorus control at point sources that directly or indirectly contribute to lakes or reservoirs. It is calculated that even complete removal of phosphorus at the point sources considered in this study would still leave a loading rate of nearly 7.9 $g/m^2/yr$ (about 3½ times the eutrophic rate).

While a high level of point-source phosphorus control would be expected to result in at least some improvement in the trophic condition of Lake St. Croix, it appears that attention will have to be given to non-point sources as well if an optimal level of phosphorus reduction is to be achieved (see below).

2. Non-point sources--It is estimated that about 88% of the total phosphorus load during the sampling year was contributed

by non-point sources. The mean non-point phosphorus exports of the various subdrainages do not appear to be excessive (see page 14), but the rather high drainage area to lake area ratio of 600 to 1 ensures a significant loading rate from non-point sources alone. Note that even the low phosphorus export of unimpacted Trout Brook (22 lbs $P/mi^2/yr$), if applied to the entire drainage, would result in a lake loading rate of about 21 lbs/acre/yr or 2.3 $g/m^2/yr$.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS

A. Lake Morphometry†:

1. Surface area: 8,209 acres.
2. Mean depth: 28.8 feet.
3. Maximum depth: 78 feet.
4. Volume: 236,419 acre/feet.
5. Mean hydraulic retention time: 23 days.

B. Tributary and Outlet:
(See Appendix A for flow data)

1. Tributaries -

Name	Drainage area*	Mean flow*
St. Croix River	6,550.0 mi^2	4,472.7 cfs
Valley Branch Stream (B-1)	13.0 mi^2	9.7 cfs
Trout Brook	11.0 mi^2	2.6 cfs
Kinnickinnic River	167.0 mi^2	95.3 cfs
Willow River	263.0 mi^2	41.0 cfs
Minor tributaries & immediate drainage -	683.2 mi^2	471.7 cfs
Totals	7,687.2 mi^2	5,093.0 cfs

2. Outlet -

St. Croix River	7,700.0 mi^2**	5,093.0 cfs

C. Precipitation***:

1. Year of sampling: 31.4 inches.
2. Mean annual: 30.9 inches.

† DNR lake survey map (1970); mean depth by random-dot method.
* Drainage areas are accurate within ±5%; mean daily flows are accurate within ±10%; and ungaged flows are accurate within ±10 to 25% for drainage areas greater than 10 mi^2.
** Includes area of lake.
*** See Working Paper No. 1, "Survey Methods".

III. LAKE WATER QUALITY SUMMARY

Lake St. Croix was sampled three times during the open-water season of 1972 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from three stations on the lake and from two or more depths at each station (see map, page vi). During each visit, a single depth-integrated (15 feet or near bottom to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the last visit, a single five-gallon depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 15 feet at station 1, 71 feet at station 2, and 28 feet at station 3.

The results obtained are presented in full in Appendix B, and the data for the fall sampling period, when the lake essentially was well-mixed, are summarized below. Note, however, the Secchi disc summary is based on all values.

For differences in the various parameters at the other sampling times, refer to Appendix B.

A. Physical and chemical characteristics:

Parameter	Minimum	Mean	Median	Maximum
		FALL VALUES (11/04/72)		
Temperature (Cent.)	5.0	6.2	6.4	7.0
Dissolved oxygen (mg/l)	10.0	10.5	10.5	10.8
Conductivity (µmhos)	203	209	210	215
pH (units)	7.5	7.5	7.5	7.6
Alkalinity (mg/l)	74	76	76	78
Total P (mg/l)	0.027	0.031	0.030	0.038
Dissolved P (mg/l)	0.014	0.017	0.017	0.022
NO_2 + NO_3 (mg/l)	0.190	0.212	0.200	0.250
Ammonia (mg/l)	0.050	0.080	0.080	0.110
		ALL VALUES		
Secchi disc (inches)	36	44	36	60

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Number per ml
06/28/72	1. Melosira	1,039
	2. Achnanthes	783
	3. Dinobryon	693
	4. Stephanodiscus	437
	5. Flagellates	376
	Other genera	1,582
	Total	4,910
08/26/72	1. Dinobryon	2,532
	2. Cyclotella	1,338
	3. Chroococcus	524
	4. Melosira	289
	5. Pediastrum	271
	Other genera	1,086
	Total	6,040
11/04/72	1. Cyclotella	2,264
	2. Dinobryon	1,396
	3. Flagellates	1,057
	4. Melosira	1,057
	5. Asterionella	830
	Other genera	2,830
	Total	9,434

2. Chlorophyll a -
(Because of instrumentation problems during the 1972 sampling, the following values may be in error by plus or minus 20 percent.)

Sampling Date	Station Number	Chlorophyll a (µg/l)
06/28/72	01	16.1
	02	32.3
	03	20.0
08/26/72	01	2.7
	02	3.7
	03	2.3
11/04/72	01	5.5
	02	5.7
	03	3.9

C. Limiting Nutrient Study:

Because of a loss of about 20% of the inorganic nirogen in the assay sample between the time of collection and the beginning of the assay, the results are not indicative of lake conditions at the time of sampling. The lake data indicate that phosphorus was limiting in November (N/P ratio = 17/1), and nitrogen was limiting in June (N/P = 7/1) and August (N/P = 9/1).

IV. NUTRIENT LOADINGS
(See Appendix C for data)

For the determination of nutrient loadings, the Minnesota National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page vi), except for May when extra samples were collected. Sampling was begun in October, 1972, and was completed in September, 1973.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Minnesota District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loadings for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated by using the means of the nutrient loads, in lbs/mi^2/year, at stations B-1 and C-1 and multiplying the means by the ZZ area in mi^2.

The operators of the Stillwater, Bayport, and Oak Park Heights, Minnesota, wastewater treatment plants provided monthly effluent samples and corresponding flow data. However, the communities of Taylors Falls, Minnesota, and St. Croix Falls, Hudson, New Richmond, and River Falls, Wisconsin, did not participate in the Survey, and nutrient loads from these sources were estimated at 2.5 lbs P and 7.5 lbs N/capita/year.

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* See Working Paper No. 1.

In the following loading tables, the nutrient loads attributed to the St. Croix River are those measured at station A-1 minus the Taylors Falls and St. Croix Falls estimated loads; and the loads given for the Kinnickinnic River are those measured at station D-1 minus the estimated River Falls loads.

However, the estimated phosphorus load from the New Richmond treatment plant (9,250 lbs P/yr) was over twice that measured at the outlet station (E-1) of the Willow River (4,480 lbs P/yr), indicating a rather high degree of phosphorus sedimentation and/or biological assimilation in the river and in Lake Mallalieu. Therefore, in this report, it is assumed that one-half of the load measured at E-1 is attributable to New Richmond and the rest is due to non-point sources. Note, however, nitrogen loads were not likewise adjusted; the nitrogen load attributed to the Willow River is that measured at E-1 minus the estimated New Richmond load.

The septic tank loads were estimated on the basis of the combined populations of Lakeland, St. Croix Beach, and Afton (1970 Census) at 0.25 lbs P and 9.4 lbs N/capita/year.

A. Waste Sources:

1. Known Minnesota municipal† -

Name	Pop. Served	Treatment	Mean Flow (mgd)	Receiving Water
Taylors Falls	587	trickling filter	0.059*	St. Croix River
Stillwater	11,205	act. sludge	1.825	Lake St. Croix
Oak Park Hts.	1,238	act. sludge	0.470	Lake St. Croix
Bayport	3,110	act. sludge	0.420	Lake St. Croix

2. Known Wisconsin municipal** -

Name	Pop. Served	Treatment	Mean Flow (mgd)	Receiving Water
St. Croix Falls	1,425	trickling filter	0.271	St. Croix River
New Richmond	3,700	trickling filter	0.356	Willow River
Hudson	6,590	trickling filter	0.400	Lake St. Croix
River Falls	7,230	trickling filter	0.695	Kinnickinnic River

3. Industrial - Unknown

† Anonymous, 1974.
* Estimated at 100 gal/capita/day.
** Wisconsin STP data from McKersie, et al., 1972.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	lbs P/ yr	% of total
a. Tributaries (non-point load) -		
St. Croix River	530,160	81.4
Valley Branch Stream (B-1)	600	<0.1
Trout Brook	240	<0.1
Kinnickinnic River	17,440	2.7
Willow River	2,240	0.3
b. Minor tributaries & immediate drainage (non-point load) -	23,230	3.6
c. Known municipal STP's -		
Taylors Falls	1,470	0.2
Stillwater	14,030	2.2
Oak Park Heights	13,020	2.0
Bayport	6,590	1.0
St. Croix Falls	3,560	0.5
New Richmond	2,240	0.3
Hudson	16,480	2.5
River Falls	18,080	2.8
d. Septic tanks* -	580	<0.1
e. Industrial - Unknown	-	-
f. Direct precipitation** -	1,280	0.2
Total	651,240	100.0

2. Outputs -

Lake outlet - St. Croix River 439,130

3. Net annual P accumulation - 212,110 pounds

* Estimated 2,320 contributing population (see page 9).
** See Working Paper No. 1.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	lbs N/ yr	% of total
a. Tributaries (non-point load) -		
St. Croix River	10,101,250	80.5
Valley Branch Stream (B-1)	45,550	0.4
Trout Brook	8,820	<0.1
Kinnickinnic River	449,860	3.6
Willow River	110,880	0.9
b. Minor tributaries & immediate drainage (non-point load) -	1,470,930	11.7
c. Known municipal STP's -		
Taylors Falls	4,400	<0.1
Stillwater	71,530	0.6
Oak Park Heights	25,870	0.2
Bayport	21,100	0.2
St. Croix Falls	10,690	<0.1
New Richmond	27,750	0.2
Hudson	49,420	0.4
River Falls	54,220	0.4
d. Septic tanks* -	21,810	0.2
e. Industrial - Unknown	-	-
f. Direct precipitation** -	79,090	0.6
Total	12,553,170	100.0

2. Outputs -

Lake outlet - St. Croix River 12,399,580

3. Net annual N accumulation - 153,590 pounds

* Estimated 2,320 contributing population (see page 9).
** See Working Paper No. 1.

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	lbs P/mi^2/yr	lbs N/mi^2/yr
St. Croix River	81	1,542
Valley Branch Stream (B-1)	46	3,504
Trout Brook	22	802
Kinnickinnic River	104	2,694

E. Yearly Loading Rates:

In the following table, the existing phosphorus loading rates are compared to those proposed by Vollenweider (in press). Essentially, his "dangerous" rate is the rate at which the receiving waters would become eutrophic or remain eutrophic; his "permissible" rate is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic rate would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with very short hydraulic retention times.

Units	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
lbs/acre/yr	79.3	25.8	1,529.2	18.7
grams/m^2/yr	8.89	2.90	171.4	2.1

Vollenweider loading rates for phosphorus ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Lake St. Croix:

"Dangerous" (eutrophic rate)	2.20
"Permissible" (oligotrophic rate)	1.10

V. LITERATURE REVIEWED

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VII. APPENDICES

APPENDIX A

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR MINNESOTA 10/30/74

LAKE CODE 27A7 ST. CROIX LAKE

TOTAL DRAINAGE AREA OF LAKE 7700.00

TRIBUTARY	SUB-DRAINAGE AREA	NORMALIZED FLOWS JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
27A7A1	6550.00	2144.2	2154.0	4257.0	10303.0	8173.0	6431.0	4210.0	2971.0	3598.0	3536.0	3272.0	2539.0	4472.6
27A7A2	7700.00	3024.1	3093.1	4449.7	12565.0	10107.0	7366.4	3916.2	3260.6	3584.8	3003.7	3501.3	3244.7	5093.0
27A7A1	13.00	8.00	8.20	11.30	12.00	10.00	11.50	10.00	9.50	9.00	9.50	9.00	8.50	9.69
27A7C1	11.00	0.24	0.25	1.56	11.60	6.50	5.50	1.75	1.00	2.00	1.50	0.27	0.26	2.64
27A7D1	167.00	69.10	67.50	256.00	93.90	83.90	114.00	69.20	70.60	70.00	74.60	85.90	80.70	95.29
27A7E1	263.00	29.70	30.00	110.00	40.40	36.00	51.20	29.80	30.40	30.10	32.00	36.90	34.70	40.96
27A777	696.00	280.00	286.00	412.00	1164.00	936.00	682.00	363.00	304.00	332.00	278.00	324.00	301.00	471.68

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 7700.00
SUM OF SUB-DRAINAGE AREAS = 7700.00

TOTAL FLOW IN = 61072.54
TOTAL FLOW OUT = 61136.59

MEAN MONTHLY FLOWS AND DAILY FLOWS

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
27A7A1	10	72	5145.00	14	5800.00				
	11	72	6767.00	5	9600.00				
	12	72	3016.00	2	3200.00				
	1	73	3220.00						
	2	73	2970.00	4	4100.00				
	3	73	12100.00	4	2900.00				
	4	73	7763.00	4	7400.00				
	5	73	8347.00	2	5900.00	20	5300.00		
	6	73	5943.00	9	7100.00				
	7	73	2700.00	18	2400.00				
	8	73	4160.00	12	5200.00				
	9	73	3900.00	24	4200.00				
27A7A2	10	72	6688.00	14	7540.00				
	11	72	8747.00	5	12500.00				
	12	72	3921.00	2	4160.00				
	1	73	4130.00						
	2	73	3850.00	3	4010.00				
	3	73	15700.00	4	65500.00				
	4	73	9200.00	8	9740.00				
	5	73	9800.00	2	6960.00	19	6170.00	20	6170.00
	6	73	7000.00	9	8330.00				
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	9	73	4400.00	24	4700.00				

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TRIBUTARY FLOW INFORMATION FOR MINNESOTA 10/30/74

LAKE CODE 27A7 ST. CROIX LAKE

MEAN MONTHLY FLOWS AND DAILY FLOWS

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
27A7B1	10	72	9.25	14	8.90				
	11	72	9.80	5	12.00				
	12	72	9.00	2	9.00				
	1	73	9.40						
	2	73	9.30	3	9.20				
	3	73	10.60	4	9.50				
	4	73	10.10	8	10.00				
	5	73	10.70	2	13.00	20	9.30		
	6	73	9.10	9	8.60				
	7	73	9.00	18	9.10				
	8	73	12.00	12	0.0				
	9	73	14.00	29	20.00				
27A7C1	10	72	0.78	14	0.60				
	11	72	0.31	5	0.70				
	12	72	0.28	2	0.30				
	1	73	0.63						
	2	73	0.30	3	0.30				
	3	73	1.52	4	0.80				
	4	73	26.50	8	21.00				
	5	73	6.63	2	16.00	20	2.60		
	6	73	1.87	9	1.40				
	7	73	1.60	28	1.60				
	8	73	1.30	12	1.10				
	9	73	3.00	29	4.50				
27A7D1	10	72	108.00	14	123.00				
	11	72	178.00	5	252.00				
	12	72	96.00	2	102.00				
	1	73	102.00						
	2	73	93.20	3	97.00				
	3	73	727.00	4	3030.00				
	4	73	70.40						
	5	73	86.40	2	49.00	20	54.00		
	6	73	109.00	9	130.00				
	7	73	44.30	14	39.40				
	8	73	97.40	12	124.00				
	9	73	75.60	29	80.90				
27A7E1	10	72	46.40	14	53.00				
	11	72	76.50	5	108.00				
	12	72	41.30	2	44.00				
	1	73	43.90						
	2	73	40.10	3	42.00				
	3	73	313.00	4	1303.00				
	4	73	30.30	8	29.00				
	5	73	37.20	2	26.00	20	23.00		
	6	73	46.90	9	56.00				
	7	73	19.00	18	16.90				
	8	73	41.90	12	53.30				
	9	73	32.50	29	34.80				

TRIBUTARY FLOW INFORMATION FOR MINNESOTA 10/30/74

LAKE CODE 27A7 ST. CROIX LAKE

MEAN MONTHLY FLOWS AND DAILY FLOWS

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
27A7Z7	10	72	463.00	14	522.00				
	11	72	609.00	5	864.00				
	12	72	271.00	2	288.00				
	1	73	290.00						
	2	73	267.00	3	279.00				
	3	73	1090.00	4	261.00				
	4	73	700.00	8	666.00				
	5	73	750.00	2	531.00	19	477.00	20	477.00
	6	73	530.00	9	639.00				
	7	73	243.00	18	216.00	28	468.00		
	8	73	369.00	12	378.00				
	9	73	351.00						

APPENDIX B

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 74/10/30

27A701
44 54 00.0 092 46 25.0
ST CROIX LAKE
27 MINNESOTA

11EPALES 2111202
3 0017 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/06/28	17	30 0000	22.6	10.2	60	165	7.63	82	0.060	0.050	0.032	0.020
	17	30 0015	20.9	7.7		150	7.37	81	0.130	0.110	0.036	0.025
72/08/26	14	30 0000			36	143	7.00	61	0.230	0.200	0.066	0.063
	14	30 0004	21.0	5.3		140	7.10					
	14	30 0015	21.0	5.4		140	7.10	60	0.250	0.210	0.061	0.049
72/11/04	14	30 0000			48	215	7.50	76	0.240	0.110	0.034	0.020
	14	30 0004	6.5	10.4		205	7.50	78	0.250	0.110	0.038	0.021
	14	30 0008	6.5	10.4		210	7.50	78	0.240	0.100	0.038	0.022

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/06/28	17	30 0000	16.1J
72/08/26	14	30 0000	2.7J
72/11/04	14	30 0000	5.5J

J VALUE KNOWN TO BE IN ERROR

STORET RETRIEVAL DATE 74/10/30

27A702
44 57 20.0 092 45 30.0
ST CROIX LAKE
27 MINNESOTA

11EPALES
3

2111202
0075 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/06/28	17	50 0000	22.9	9.2	36	145	7.28	71	0.040	0.050	0.046	0.026
	17	50 0015	20.4	7.7		145						
	17	50 0025	19.8	6.1		150	7.20	79	0.190	0.130	0.046	0.034
72/08/26	14	50 0000			36	130	7.15	56	0.230	0.200	0.074	0.047
	14	50 0004	20.0	5.3		128	7.20	56	0.230	0.180	0.075	0.043
	14	50 0015	19.9	5.3		125	7.20	55	0.230	0.190	0.072	0.044
	14	50 0021	19.9	4.6		121	7.20	52	0.230	0.180	0.070	0.038
	14	50 0031	19.8	5.4		121	7.20	53	0.240	0.180	0.069	0.042
	14	50 0041	19.9	5.4		123	7.20	53	0.240	0.190	0.071	0.043
	14	50 0051	19.8	5.4		120	7.20	53	0.240	0.170	0.071	0.040
	14	50 0061	19.8	5.6		120	7.20	52	0.240	0.170	0.069	0.042
	14	50 0071	19.1	5.6		120	7.20	51	0.240	0.170	0.068	0.042
72/11/04	14	45 0000			58	210	7.60	78	0.210	0.080	0.030	0.017
	14	45 0004	6.5	10.6		210	7.60	77	0.210	0.080	0.034	0.017
	14	45 0015	6.4	10.4		208	7.50	76	0.200	0.070	0.030	0.016
	14	45 0025	6.4	10.2		208	7.50	76	0.200	0.080	0.031	0.019
	14	45 0045	6.4	10.0		212	7.50	77	0.210	0.080	0.030	0.015
	14	45 0068	6.4	10.8		210	7.50	77	0.200	0.070	0.031	0.018

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/06/28	17	50 0000	32.3J
72/08/26	14	50 0000	3.7J
72/11/04	14	45 0000	5.7J

J VALUE KNOWN TO BE IN ERROR

STORET RETRIEVAL DATE 74/10/30

27A703
45 01 52.0 092 46 07.0
ST CROIX LAKE
27 MINNESOTA

11EPALES 2111202
3 0022 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/06/28	18 15	0000	26.0	8.0	36	140	7.23	72	0.060	0.120	0.060	0.036
	18 15	0015	21.4	7.4		135	7.28	71	0.080	0.130	0.055	0.036
72/08/26	15 40	0000			36	120	7.30	50	0.250	0.140	0.087	0.054
	15 40	0004	19.4	6.5		120	7.20	49	0.240	0.130	0.084	0.052
	15 40	0015	18.3	6.2		120	7.20	49	0.250	0.140	0.080	0.054
	15 40	0021	18.2	6.3		120	7.20	48	0.240	0.140	0.087	0.052
	15 40	0028	18.1	6.1		120	7.20	55	0.250	0.160	0.092	0.055
72/11/04	15 15	0000			47	215	7.50	74	0.200	0.090	0.029	0.015
	15 15	0004	7.0	10.6		208	7.50	75	0.190	0.060	0.027	0.017
	15 15	0015	5.0	10.6		203	7.50	76	0.200	0.050	0.028	0.014
	15 15	0026	5.0	10.6		205	7.50	76	0.200	0.060	0.029	0.014

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/06/28	18 15	0000	20.0J
72/08/26	15 40	0000	2.3J
72/11/04	15 15	0000	3.9J

J VALUE KNOWN TO BE IN ERROR

APPENDIX C

TRIBUTARY and WASTEWATER TREATMENT PLANT DATA

STORET RETRIEVAL DATE 74/10/30

27A7A1 LS27A7A1
45 03 30.0 092 48 00.0
ST CROIX RIVER
27 7.5 STILLWATER
I/LAKE ST CROIX
AT INT BRDG BETW STILLWATER& HOULTON
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/14	14 30		0.180	[illegible]	0.062	0.014	0.050
72/11/05	12 30		0.234	[illegible]	0.138	0.017	0.056
73/04/09	10 00		0.690	1.[illegible]0	0.013	0.012	0.040
73/05/02	20 15		0.070	0.470	0.010	0.006	0.050
73/05/20	14 00		0.061	1.100	0.005K	0.011	0.050
73/06/09	14 00		0.075	1.300	0.016	0.012	0.057
73/07/18	17 00		0.010K	0.720	0.013	0.013	0.055
73/08/12	11 45		0.010K	1.260	0.021	0.014	0.057
73/09/29	09 00		0.140	0.840	0.049	0.026	0.085

K VALUE KNOWN TO BE LESS THAN INDICATED

STORET RETRIEVAL DATE 74/10/30

27A7A2 27A4E1
44 46 00.0 092 49 00.0
ST CROIX RIVER
27 7.5 PRESCOT/WAST
O/LAKE ST CROIX
US 10 BRDG E PRESCOTT WI
11FPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/14			0.424	0.850	0.079	0.038	0.075
72/11/05	13 30		0.310	0.720	0.115	0.025	0.050
72/12/02	15 25		0.294	0.680	0.046	0.019	0.044
73/01/14	13 00		0.560	1.260	0.130	0.024	0.035
73/02/03	13 40		0.600	1.600	0.088	0.027	0.035
73/03/04	13 30		0.670	1.540	0.058	0.021	0.035
73/04/08	11 00		0.280	0.750	0.054	0.020	0.050
73/05/02	19 30		0.043	0.740	0.060	0.007	0.050
73/05/19	10 40		0.010K	0.540	0.005K	0.005K	0.045
73/05/20	15 10		0.065	1.200	0.010	0.007	0.035
73/06/09	15 00		0.350	1.100	0.132	0.019	0.040
73/07/18	17 45		0.126	0.690	0.022	0.005K	0.015
73/08/12	10 30		0.010K	1.000	0.010	0.011	0.040
73/09/29	09 45		0.340	0.360	0.027	0.031	0.055

K VALUE KNOWN TO BE LESS THAN INDICATED

STORET RETRIEVAL DATE 74/10/30

27A7B1 LS27A7B1
44 54 30.0 092 46 00.0
VALLEY BRANCH STREAM
27 7.5 HUDSON
T/LAKE ST CROIX
ST HWY 95 BRDG BETW AFTON &ST MARYS PT
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/14	15 30		0.380	0.100K	0.043	0.013	0.028
72/11/05	13 20		0.690	0.100K	0.018	0.016	0.026
72/12/07	14 45		2.400	0.100K	0.025	0.012	0.021
73/01/14	12 20		2.700	0.100K	0.021	0.015	0.020
73/02/03	13 00		2.500	0.540	0.053	0.010	0.020
73/03/04	12 45		2.500	2.750	0.320	0.060	0.080
73/04/08	10 30		2.200	0.100K	0.007	0.008	0.015
73/05/02	19 00		1.650	0.520	0.011	0.005K	0.030
73/05/20	14 30		1.900	0.630	0.035	0.014	0.040
73/06/09	14 30		1.040	1.100	0.052	0.032	0.040
73/07/18	17 15		2.040	0.340	0.013	0.013	0.025
73/08/13	09 45		2.040	0.100K	0.016	0.016	0.025
73/09/29	09 15		2.120	0.170	0.014	0.019	0.035

K VALUE KNOWN TO BE LESS
THAN INDICATED

STORET RETRIEVAL DATE 74/10/30

27A7C1 LS27A7C1
44 51 30.0 092 46 30.0
TROUT BROOK
27 7.5 PRESCOTT
T/LAKE ST CROIX
CO HWY 21 2.5 MI S OF AFTON
11FPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/14	15 55		0.280	1.350	0.050	0.034	0.072
72/11/05	13 15		0.420	0.210	0.021	0.029	0.046
72/12/02	15 00		1.960	0.100K	0.008	0.033	0.056
73/01/14	12 40		1.960	0.100K	0.016	0.024	0.025
73/02/03	13 20		1.960	0.600	0.024	0.027	0.030
73/04/08	10 45		1.660	0.110	0.007	0.021	0.025
73/05/02	19 15		1.440	0.430	0.026	0.074	0.160
73/05/20	14 45		1.040	1.100	0.010	0.017	0.035
73/06/04	14 45		0.810	1.000	0.040	0.019	0.035
73/07/24	17 30		1.220	0.160	0.024	0.026	0.045
73/08/12	10 15		1.420	0.130	0.009	0.027	0.040
73/09/20	09 30		1.640	0.400	0.012	0.038	0.065

K VALUE KNOWN TO BE LESS THAN INDICATED

STORET RETRIEVAL DATE 74/10/30

27A7D1 LS27A7D1
44 46 30.0 092 44 00.0
KINNICKINNIC RIVER
27 PIERCE CO MAP
T/LAKE ST CROIX
CO HWY F 4MUG NNE PRESCOT 5MI WSW R FALS
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO3&NO2 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/14	16 50		0.480	0.100K	0.042	0.170	0.210
72/11/05	14 00		0.730	0.280	0.061	0.128	0.173
72/12/02	15 30		2.900	0.176	0.176	0.180	0.220
73/01/14	13 20		3.400	0.280	0.096	0.115	0.150
73/02/03	14 00		3.100	0.260	0.147	0.126	0.155
73/03/04	13 45		2.900	2.400	0.399	0.180	0.240
73/05/02	19 45		1.740	1.700	0.160	0.132	0.345
73/07/18	20 00		2.300	0.100K	0.010	0.094	0.130
73/08/12	10 45		2.700	0.110	0.007	0.076	0.105
73/09/29	10 00		0.945	0.120	0.017	0.120	0.150

K VALUE KNOWN TO BE LESS THAN INDICATED

STORET RETRIEVAL DATE 74/10/30

27A7E1 LS27A7E1
44 59 00.0 092 45 30.0
LAKE MALLALIEU
27 7.5 HUDSON
T/LAKE ST CROIX
AT HUDSON CITY BRDG
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/14	15 00		0.042	1.250	0.044	0.008	0.069
72/11/05	12 45		0.450	1.260	0.027	0.007	0.054
72/12/02	14 25		1.200	0.560	0.013	0.010	0.056
73/01/14	12 00		2.060	0.140	0.094	0.035	0.040
73/02/03	14 20		2.000	1.470	0.096	0.038	0.045
73/03/04	12 30		2.000	0.960	0.102	0.032	0.040
73/04/08	10 15		0.096	0.660	0.010	0.012	0.040
73/05/02	20 00		0.180	1.150	0.013	0.008	0.070
73/05/20	14 15		0.430	1.680	0.036	0.006	0.060
73/06/04	14 15		0.400	1.150	0.022	0.005K	0.065
73/07/18	20 15		0.040	1.100	0.006	0.013	0.070
73/08/13	11 00		0.010K	0.750	0.005K	0.013	0.050
73/09/29	10 15		0.480	0.760	0.027	0.013	0.060

K VALUE KNOWN TO BE LESS
THAN INDICATED .

STORET RETRIEVAL DATE 74/10/30

27A751 P027A751 P010191
45 02 25.0 092 47 30.0
STILLWATER
27 7.5 STILLWATER
D/LAKE ST CROIX
LAKE ST CROIX
11EPALES 2141204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
73/02/26	11 00								
CP(T)-			0.120	13.000	2.600	2.400	3.100	1.990	2.100
73/02/26	13 00								
73/03/06	11 00								
CP(T)-			0.945	12.600	0.970	2.100	3.150	2.500	2.200
73/03/06	13 00								
73/04/04	11 00								
CP(T)-			0.600	0.480	0.077	1.930	2.450	1.530	1.600
73/04/04	13 00								
73/05/03	11 00								
CP(T)-			0.035	6.600		2.200	2.800	1.550	2.010
73/05/03	13 00								
73/06/01	11 00								
CP(T)-			0.159	8.800	0.285	3.360	3.700	1.000	1.200
73/06/01	13 00								
73/07/02	11 00								
CP(T)-			1.000	7.800	0.890		1.050	2.500	2.000
73/07/02	13 00								
73/08/07	11 00								
CP(T)-			0.040	12.600	2.520	3.400	4.000	1.850	1.790
73/08/07	13 00								
73/09/05	11 00								
CP(T)-			6.000	31.900				1.670	1.760
73/09/05	13 00								
73/10/01	11 00								
CP(T)-			0.290	10.500	0.110	3.700	4.000	1.670	1.960
73/10/01	13 00								
73/12/03	00 00								
CP(T)-			0.170	13.000	1.980	0.110	0.670	1.810	1.750
73/12/03	24 00								
74/01/09	11 00								
CP(T)									
7[illegible]4	13 00		0.080	10.500	3.900	0.210	1.050	1.730	1.700

STORET RETRIEVAL DATE 74/10/30

274752 P0274752 P002987
45 01 00.0 092 46 30.0
BAYPORT
27 7.5 STILLWATER
O/LAKE ST CROIX
LAKE ST CROIX
11EPALES 2141204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
73/02/26	11 00								
CP(T)-			0.045	25.000L	2.900	4.200		0.450	0.380
73/02/26	13 00								
73/03/04	11 00								
CP(T)-			0.840	9.450	1.500	1.950	2.300	0.460	0.350
73/03/04	13 00								
73/04/04	11 00								
CP(T)-			1.[illegible]40	9.400	0.700	4.350	5.300	0.440	0.430
73/04/04	13 00								
73/05/03	11 00								
CP(T)-			5.500	7.900	3.024	4.500	5.900	0.425	0.480
73/05/03	13 00								
73/06/01	11 00								
CP(T)-			10.340	9.300	1.027	5.080	6.700	0.470	0.450
73/06/01	13 00								
73/07/02	10 00								
CP(T)-			4.400	4.500	0.150	3.970	5.800	0.480	0.450
73/07/02	12 00								
73/08/07	11 00								
CP(T)-								0.535	0.520
73/08/07	13 00								
73/09/05	11 00								
CP(T)-			0.630	20.700		4.900		0.490	0.470
73/09/05	13 00								
73/10/04	11 00								
CP(T)-			9.400	2.500	0.370	7.400	7.500		0.450
73/10/04	13 00								
73/11/02	11 00								
CP(T)-			4.800	11.500	1.050	5.950	7.900	0.420	0.350
73/11/02	13 00								
73/12/03	11 00								
CP(T)-			12.900	6.900	0.210	0.370	1.850	0.370	0.420
73/12/03	13 00								

STORET RETRIEVAL DATE 74/10/30

27A753 AS27A753 P001238
45 02 00.0 092 47 30.0
OAK PARK HGHTS
27 7.5 STILLWATER
D/LAKE ST CROIX
LAKE ST CROIX
11EPALES 2141204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
73/02/26	11	00							
CP(T)-			3.600	12.400	1.680	12.600		0.162	0.136
73/02/26	13	00							
73/03/06	11	00							
CP(T)-			8.600	9.400	0.620	10.400	12.500	0.200	0.206
73/03/06	13	00							
73/04/04	11	00							
CP(T)-			9.735	11.000	0.041	13.600	14.700	0.111	0.108
73/04/04	13	00							
73/05/03	11	00							
CP(T)-			0.330	126.000	15.100	10.350	36.700	0.116	0.102
73/05/03	13	00							
73/06/01	10	00							
CP(T)-			1.300	26.000	11.190	21.900	24.000	0.102	0.980
73/06/01	12	00							
73/07/01	11	00							
CP(T)-			0.290	28.000	10.000	9.220	13.400	0.098	0.101
73/07/01	13	00							
73/11/02	11	00							
CP(T)-			0.580	10.500	0.670	3.570	4.400	1.910	1.660
73/11/02	13	00							